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Analysis of the conduction mechanism through InSb quantum dot by tunnel CVC method

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Semiconductor compounds A_3B_5 belong to the most promising and interesting from the practical point of view semiconductor materials for many years. This compounds possess a characteristic features of electrons energy spectrum and extremely low values of conduction electrons effective mass. The last thing provides the de Broglie wavelength of tens of nanometers for the conduction electrons even at room temperature. In this regard, a specific phenomena associated with the size quantization of electrons energy spectrum can manifest themselves in a relatively large structures.

Materials and methods. The properties of obtained film samples with quantum-size objects of indium antimonide were investigated by scanning tunneling microscopy (STM), scanning electron microscopy (SEM), and particle size analyzer (Malvern Mastersizer 2000). To analyze the experimental tunnel CVC, we used the dependence *(dI/dV /(I/V)* on the voltage *V*.

Results and discussion. To determine the validity of field-emission model use, we made calculations of the CVC for the InSb QD and comparison of the results with the experimental data.

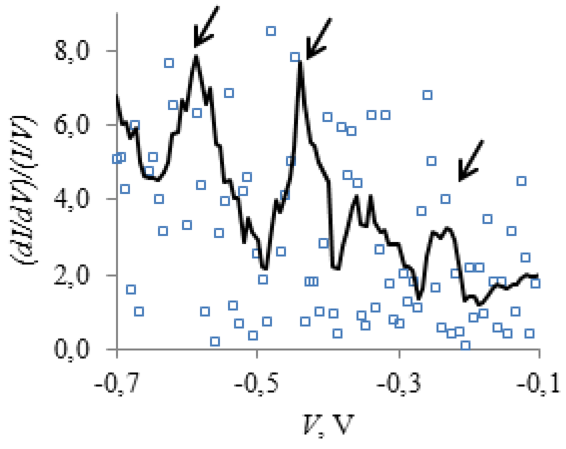
The calculations used data:

InSb: $m^* = 0{,}013m_0$, $d = 1$nm, $As = 4{,}9$ eV, $\theta = 0{,}2$

To estimate the values of the QD spectrum first three levels and, accordingly, the QD size, an analysis of the experimental data was performed by the tunnel CVC method (the dependence *(dI/dV)/(I/V)* on the voltage *V*). The results are shown in Figure 1a. The obtained values of the peaks on the normalized differential CVC were put in correspondence with the calculated energy spectrum levels with an error of up to 2*kT* (the selected area in Fig. 1b).

QD size estimates by comparison of the electronic spectrum calculation with the analysis of the experimental tunnel CVC were in the range 18-22 nm.

Calculated CVC for the field-emission model for the InSb QD with different characteristic sizes a are shown in Figure 2a. For comparison, Figure 2b shows the typical experimental CVC for *InSb* QD.



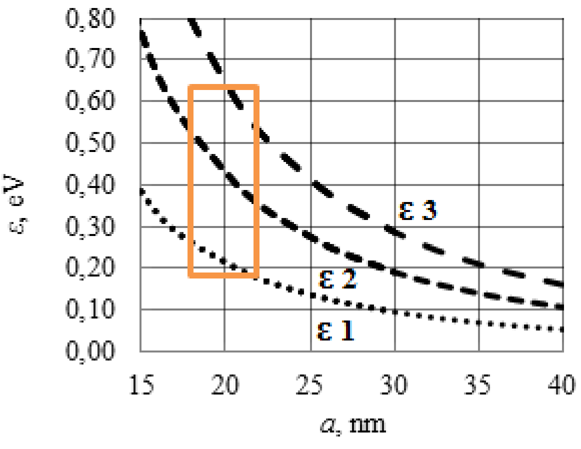


Figure 1. (a) Typical differential tunnel CVC of InSb QD, (b) calculated conduction electron energy values for the first three allowed levels of InSb QD depending on the characteristic size a by the "cubic" QD model.

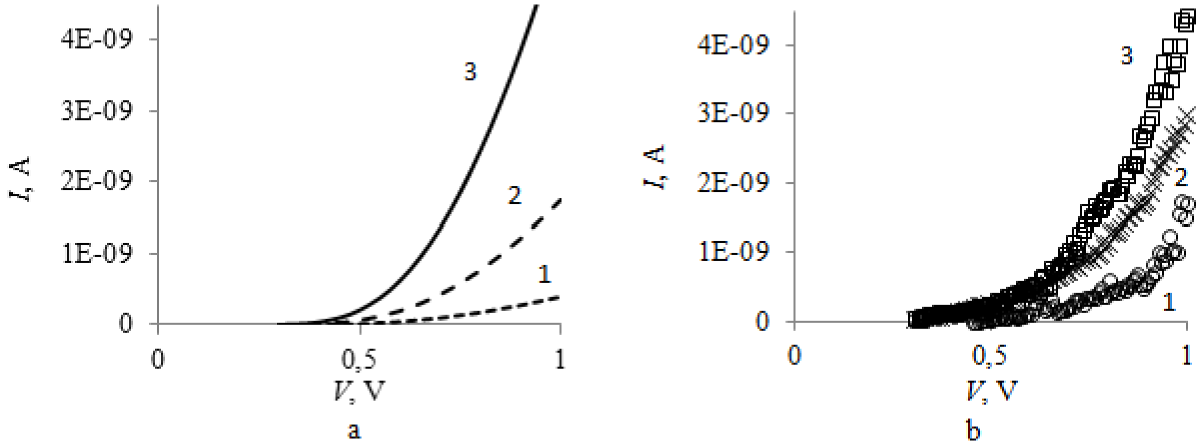


Figure 2. (a) Rated CVC for InSb QD, (b) typical experimental CVC for InSb QD.

Analysis of the experimental results and theoretical calculations showed their qualitative (CVC form) and quantitative (current values in considered voltage range) agreement. QD size estimates by the method of comparing the calculated CVC to the experimental ones (based on the field-emission model) were in the range 20-22 nm.

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1. A.I. Mikhailov, V.F. Kabanov, N.D. Zhukov, *Technical Physics Letters* **41**, 1065 (2015).
2. V.L. Mironov, *The textbook for students of the senior courses of higher educational institutions*, Nizhniy Novgorod, 97 (2004).
3. A.I. Mikhailov, V.F. Kabanov, et al., *Nanosystems: physics, chemistry, mathematics* **8**, 596 (2017).